

Additive Manufacturing, Design, Testing, and Fabrication: A Full Engineering Experience at JSC

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I worked on several projects this term. While most projects involved additive manufacturing, I was also involved with two design projects, two testing projects, and a fabrication project. The primary mentor for these was Richard Hagen. Secondary mentors were Hai Nguyen, Khadijah Shariff, and fabrication training from James Brown. Overall, my experience at JSC has been successful and what I have learned will continue to help me in my engineering education and profession long after I leave.

My 3D printing projects ranged from less than a 1cm³ to about 1ft³ and involved several printers using different printing technologies. It was exciting to become familiar with printing technologies such as industrial grade FDM (Fused Deposition Modeling), the relatively new SLA (Stereolithography), and PolyJet. My primary duty with the FDM printers was to model parts that came in from various sources to print effectively and efficiently. Using methods my mentor taught me and the Stratasys Insight software, I was able to minimize imperfections, hasten build time, improve strength for specific forces (tensile, shear, etc...), and reduce likelihood of a print-failure. Also using FDM, I learned how to repair a part after it was printed. This is done by using a special kind of glue that chemically melts the two faces of plastic parts together to form a fused interface. My first goal with SLA technology was to bring the printer back to operational readiness. In becoming familiar with the Pegasus SLA printer, I researched the leveling, laser settings, and different vats to hold liquid material. With this research, I was successfully able to bring the Pegasus back online and have successfully printed multiple sample parts as well as functional parts. My experience with PolyJet technology has been focused on an understanding of the abilities/limits, costs, and the maintenance for daily use. Still upcoming will be experience with using a composite printer that uses FDM technology to print plastic while laying an internal filament of Kevlar or carbon-fiber inside the printed material. It has been incredible being exposed to this range of technologies and I feel very fortunate to be ready for virtually any kind of printing technology I come across in the future.

Design work played a part in my internship this term as well. Working with Hai Nguyen, I was able to design a set of testing tips and a test frame for use with an Arcjet. The testing tips will be made of several different materials that will possibly be used in the heat shield of the Orion space craft. These designs included technical drawings that were presented to the fabrication shop. The frame design was created from 80/20 (a popular brand of frame construction equipment) and included an order form with pricing for fabrication. An independent design was also done for the virtual reality lab. This design was to create a hand-controller based on a previous design. This final design was sent directly to a 3D printer without technical drawings. Overall, my design work has given me experience with using 80/20, helped improve my CAD (Computer Aided Design) proficiency, and increased my knowledge of how to set up technical drawings for fabrication.

The final role I have played in this internship has been to assist with testing of the inflatable technology materials working Khadijah Shariff. I began the internship assisting with permeability testing with the initial plan to continue the testing independently after training. Unfortunately, the testing apparatus suffered a technical failure and had funding pulled which cancelled that portion of the project. Further testing with inflatable technology continued with tensile testing of various stitching methods. This testing took place over a two-days and concluded successfully. Final testing was to be more tensile testing but of straps used to connect various inflatable sections. Unfortunately, the needed grips for the tensile tests could not be located and put the testing on hold. It is possible this round of testing will still take place by the end of the internship if the grips can be found. Overall, this portion of

the internship has helped me become familiar with one kind of permeability test as well as a popular tensile/compression testing machine.

Finally, I also had the chance to be trained using a metal lathe for making very small tips for a soldering iron. These tips will be used to melt threaded brass inserts into 3D printed plastic. Working with James Brown, I was able to successfully machine a brass rod down to as little as $0.064" \pm 0.001"$. It was very rewarding to learn how to best use the machine and become familiar with a skill that will undoubtedly be used again in the future. I have been told by several professional engineers that learning to use a lathe and mill will be invaluable skills in the field. This knocks 50% of that goal off and I look forward to learning the mill at some point in the future.

As is apparent with this list of projects, my internship was not focused on a single over-arching goal. Instead, I was able to gain experience in a myriad of very different areas. I feel like my time here was spent bouncing from one project to the next. Though sometimes difficult to switch gears, it was very rewarding to be a part of so much in so little time. My career and education will be positively impacted by what I have learned at JSC. My experience with 3D printing has improved my ability to handle many issues that may come up in the future with multiple different technologies. The design work I took part in, especially creating technical drawings, will help me better present designs to any engineer or shop I will encounter. My testing experience has helped me become familiar with a popular kind of tensile test machine that will likely be similar to the kinds I will encounter in the future. Finally, my experience with fabrication has given me a rare opportunity, as an engineer, to take part in the fabrication of a part. This experience will help me better tailor my future designs for the manufacturing process and has given me an appreciation for detailed/delicate machining work. My experience at JSC has been successful and will continue to assist me for a long time within the engineering field.